Gondwanan heritage in groundwater crustaceans of peninsular India

Initially, India was nestled in the supercontinent Pangaea at high southerly latitudes between Late Paleozoic and Early Permian ca. 255 Ma (ref. 1). The Pangaea was intact during the Late Triassic and Early Jurassic periods, but the first stage of its rifting took place in the middle Jurassic period ca. 180 Ma. Before its journey into northern latitudes, the Indian plate rifted from other Gondwanaland masses at different times in the geological past1 – from Africa along with Madagascar ca. 180–170 Ma, from Antarctica–Australia ca. 130 Ma and from Madagascar ca. 90 Ma. Eventually, the docking against Asia began ca. 55–65 Ma. During its tectonic evolution from the Pangaea times to the present day, the Indian plate being both as a biotic ‘ferry’ and a biotic sink2, had experienced, inter alia, extensive exchange between peninsular autochthonous and Asian Tertiary biota3–6.

As a result, the modern terrestrial and freshwater biota of India is ‘overwhelmingly oriental’ though it harbours a few living relics, both invertebrates and vertebrates, that might date back to the pre-drift period4,8. According to Mani7, ‘The Peninsula per se is biogeographically India vera, the largest and the oldest region of differentiation of the original floras and faunas of India’.

And yet, India as a whole has remained terra incognita for groundwater fauna (stygofauna) till recently7,8. Regular stygofaunistic surveys in the country have begun since 2000, especially in the coastal deltaic belt of the rivers Krishna and Godavari, following the fortuitous discovery of two typical stygobiotic crustacean taxa: the copepod family Bathynellidae, i.e. Habrobathyella, and one genus each of the families Leptobathynellidae and Bathynellidae7. Detailed taxonomic study of the stygobiotic bathynellaceans and copepods (body length ca. 1 mm), has revealed 60-odd, mostly new species, half of which have been formally described till now. This note is mainly meant to report on the unequivocal Gondwanan heritage in these little-known taxa and also stress their importance in the overall evolutionary history of Indian biota.

Generally, all the obligate subterranean fauna (stygobiots) may be good candidates for historical biogeography. However, the crustaceans as a group are better suited for this purpose because they are dominant and widespread in the ecosystems of both karstic and alluvial aquifers. Amongst crustaceans, the members of the order Bathynellacea, in particular, have long been recognized as suitable objects for understanding the history of the earth’s crust and biological speciation, the reasons being: (i) Bathynella belong to an ancient lineage, dating back to Carboniferous; (ii) they live as unobtrusive ecological generalists; (iii) they occupy relatively inaccessible, cryptic habitats, i.e. interstitial spaces of sandy river banks, caves, etc., and (iv) have very limited powers of dispersal with no resting stages.

Incidentally, it may be mentioned here that the biogeographic studies based on stygobiots assume special importance at this juncture when the globalization of world’s economy has brought about increasing effects of homogenization of the world’s biota7. As a result, the study of biogeography, which was once ‘a pillar of evolution’, has now come to be greatly distorted by the presence of alien invasive organisms. An example is the biogeographic catastrophe that has befallen the San Francisco Bay, USA, which reportedly has some 234 invasive species, constituting about 90% of its aquatic population12. The enormous economic losses inflicted by the invasives are a different story.

The Gondwanan distribution of the stygobiotic bathynellacean and copepod genera of the peninsular India is summarized in Table 1. Amongst these crustaceans, the bathynellaceans, the ancestors of which inhabited the tropical seas during the Carboniferous times, display the Gondwanan lineage rather spectacularly. This group as a whole might have achieved its worldwide distribution prior to the breakup of Pangaea, and its present-day geographic distribution can more plausibly be explained by the vicariance model rather than by the classic dispersal model12–14. Till now, only three genera of the family Parabathyellidae, i.e. Chilibathyella, Habrobathyella and Atopobathyella, and one genus each of the families Leptobathyellidae and Bathynellidae, i.e. Parvalobathyella and Serbanibathyella respectively are known from peninsular India. The specific biogeographic patterns of these genera and their implications are briefly dealt with here.

Genus Chilibathyella: Known only by two species, viz. the Chilean Ch. clandesina and the Australian C. australiensis, this genus was considered ‘an entirely austral group’, displaying transantarctic relationships15. Also, in terms of panbiogeography, this genus was believed to belong to the southern temperate track, which connects the southern South America, Australia, Tasmania and New Zealand with Pacific basin baseline16. However, following the discovery of the Indian cavernicolous C. kotus-sarensis, the biogeographic range of the genus extends far north into the tropical belt of Northern Hemisphere17. This genus is rather rare in India as is elsewhere.

Genus Habrobathyella: Originally established for two Madagascan species (H. milloti and H. jeanneali), this genus...
is most common in peninsular India where 11 species are recorded, of which eight species have been described. The active speciation process of the \textit{Habro}\-bathynella in the river banks of peninsu-lar India is noteworthy. Prior to its discovery in peninsular India, this genus was presumed to belong to northern tropical track, connecting tropical South America and tropical Africa, having an Atlantic Ocean baseline\textsuperscript{16}. Given the fact that vast tracts of the global groundwater domain still remain unexplored, future studies are likely to unearth this genus from other Gondwana landmasses.

Genus \textit{Atopobathynella}: Five species of this genus are recorded in peninsular India, of which only one species (\textit{A. op-erculata}) has been described thus far\textsuperscript{18}. Previously, one species each from Chile, New Zealand and Tasmania, and eight from mainland Australia have been esta-

Genus \textit{Parvulobathynella}: It is a most derived genus represented by two species each in India and South Africa, and one species each in Paraguay, Chile and Ivory Coast. It is yet another iconic case of Gondwana lineage.

Genus \textit{Serbanibathynella}: This monotypic Indian taxon has its closest sister relationship with the genus \textit{Nanno-}

Not surprisingly, the Indian bathynel-

caceans show no close phylogenetic affin-

ty with their Asian counterparts. In fact, the Asian taxa are clearly plesiomorphic, which prompted Schminke\textsuperscript{15} to presume that East Asia was the centre of evolu-

tion of Bathynellacea. Recently, some of the most primitive bathynelecan taxa have turned up in Australia\textsuperscript{21,22}. Compared with Bathynellacea, Paras-

tenocarididae is a much younger group, having originated possibly in the early Tertiary or even earlier\textsuperscript{23}. Though neither

the resting stages nor the means of dis-

persal is known for parastenocaridids\textsuperscript{24},

downstream dispersal in a water course

seems probable\textsuperscript{25}. Here also, like in the
case of Bathynellacea, the vicariance events involving the continental drift rather than the subsequent dispersal events are believed to be responsible for their worldwide distribution\textsuperscript{26}. In this scenario, the composition of parasteno-
caridid fauna in peninsular India also reflects the clear-cut Gondwanan heri-
tage, as evidenced up till now by two

parastenocaridid genera: \textit{Kinne caris}

(Schminke) and \textit{Siolicaris}. The former is

represented in India by \textit{K. godavari}\textsuperscript{27},

whereas its congeners occur all along the
eastern side of Africa from Ethiopia
down to South Africa, and also in

West Africa, Madagascar, Western Aus-

tralia and Papua New Guinea\textsuperscript{28}. \textit{Sioli-
caris}, which is under revision (P. H. C.
Corgosinho, pers. commun.), is so

far known in India by \textit{S. sandhya}\textsuperscript{2},

whereas the other known species are

neotropical.

Furthermore, two genera of the copepod

family Cyclopidae, viz. \textit{Haplocyclops}\textsuperscript{29}

and \textit{Ryhylocyclops}\textsuperscript{30} and one genera of

another copepod family Cyclopinidae, viz. \textit{Allo-
cyclopina}\textsuperscript{31}, are represented in pen-

insular India by a single described speci-
cess each. Interestingly enough, all these
three genera have their type species in

Madagascar. \textit{Haplocyclops} also occurs in

Brazil and Iran. Biogeographically, the

reported occurrence in Iran of a species of

\textit{Haplocyclops} (here, \textit{H. iranicus})\textsuperscript{32},
is certainly incongruous. The morphology

of this species and its generic affinities

need to be re-examined. Madagascar

apart, \textit{Allo cyclopina} has been reported from

Reunion Island and South Australia.

What is surprising about the Indian

groundwater Crustacea as a whole is that

this widespread group does not have any

peculiar genera despite the traditional

assumption that India as an isolated con-
tinent existed far out in the Tethys Sea

for about 100 Ma (ref. 3). Another co-
nundrum thrown up by this group is the

utter truancy of the likes of the basal

bathynelecan taxa of Australia such as

\textit{Bililibathynella} and \textit{Brevisomabathynella}

nor even the cosmopolitan \textit{Hexa-
bathynella}. Phylogenetically, this fauna

is much less diversified in India vis-à-vis

Australia\textsuperscript{33}.

All in all, the Indian stygobiotic crust-
aceans typify the Gondwanan heritage.

These tiny ancient unique creatures in

the hypogean realm are no less important

than the epigean charismatic vertebrates

in understanding the evolutionary history

of the earth crust. However, their existence

is now threatened, \textit{inter alia}, by the indis-

criminate sand-mining activity through-

out the country. Sand miners are digging

to a depth of 15 m or so with the help of

machines and even extracting the earth

after touching the river floor. The Andhra

Pradesh state Government policy pro-
vides for banning the use of machinery

and restricting the depth of sand extrac-
tion\textsuperscript{3} to 2 m, though most of the hypo-

heic diversity exists in the upper one

meter or so.

Undoubtedly, the vast, ancient and

ecologically highly-diversified Indian

aquatic subterranean domain is a verita-
le treasure trove of faunal wealth, to

which little attention has been paid thus

far. Subterranean biology as a thrust

area of basic research deserves the rapid

response of the funding agencies, re-

searchers, policy makers and land man-

agers.

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MEETINGS/SYMPOSIA/SEMINARS

National Symposium on Biopharmaceuticals – Their Application in Disease Prevention and Health Promotion (NSBP 2011)

Date: 4–5 August 2011
Place: Coimbatore

The symposium aims to provide an arena to convene scientists, physicians, post doctoral fellows, academicians, young research scholars in medical, pharmacy, nursing, microbiology, biochemistry, biotechnology, clinical lab technology, biopharmaceutical professional, researchers from pharmaceutical company, faculty and scholars from research and development departments of government and private organization.

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National Symposium on Nanoscience and Technology (NANOSTECH 2011)

Date: 1–2 September 2011
Place: Muvattupuzha

Topics include: Synthesis and fabrication of nanomaterials; Advanced nanomaterials; Nanoelectronics; Nanobiotechnology; Nanocatalysis; Nanosensors; Nanomedicine; Carbon nanostructures; Nano applications; Nanotechnology – microbiology interface; Nanophotonics; Nanoparticles: from biosynthesis to biomedical applications.

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